

VITAMINS IN HUMAN NUTRITION¹

I

VITAMINS: THE SPARK PLUGS OF THE BODY

THE food of man, like his labors and pleasure, has undergone great changes during the half-million years or more since our ancestors fought out their struggle for existence with mammoths and cave bears instead of tax collectors and strike organizers. In the days of leopard-skin dinner jackets, when daylight-saving time and nudism were in their original heyday, man lived on a good variety of meat, fish, insects, shellfish, fruits, seeds, tubers, and sprouts—whatever he could knock down or pick up with the minimum of effort or thought. At the dawn of civilization and ever since, with all due respect to the orators who speak of the “right” to work, and extol work as a divine blessing, man, like every other animal on the earth, has endeavored to get his daily rations and other necessities and pleasures with the least possible expenditure of energy.

It was easier to herd sheep and goats than to chase antelopes through the jungle, and easier to collect the grain from concentrated fields of corn or rice than to roam for miles to collect enough herbs or roots to satisfy a gnawing stomach. Thus animal husbandry and agriculture developed and man's food became less varied. But it was not until even later days, when men found it easier to work in mills, or sail in ships, or write books, or even sit on flagpoles, than to hoe corn or

¹A series of current popular lectures by Asa Crawford Chandler, Ph.D. (California), Professor of Biology at the Rice Institute.

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herd sheep, that the diet became sufficiently restricted or sufficiently manipulated to make deficiencies develop to an appreciable extent.

Diseases now recognized as due to dietary deficiencies have lost their birth certificates, but they date back to at least 2600 years B.C., when a Chinese author wrote a description of beri-beri. Eye troubles and night blindness were described in ancient Chinese and Egyptian writings, and remedies prescribed for them. The Egyptians fed liver as a cure, but the Chinese put their faith in concoctions made from droppings of flying foxes and bats. Both prescriptions are rich in vitamin A, lack of which is now known to be the cause of these eye troubles. Ever since men have been going down to the sea in ships, scurvy has been a curse of the seafarer, and was variously attributed to exposure to cold, to sea air, to salted meats, or to annoyed deities.

"Spring fever," through the ages, has driven farmers to eat the first sorrel or dandelion greens that followed the melting snows to satisfy a craving for vitamin A, lack of which was very common during winter days before the era of canned and frozen vegetables banished the seasons as far as this vitamin is concerned.

In the case of nearly all fundamentally important scientific discoveries, a few accurate observers hit upon truths which become established facts only after years of labor and experiment, while a few clairvoyant thinkers actually hurdle decades or even centuries to make startlingly accurate predictions. So it has been with the discovery of vitamins. It was not, however, until the twentieth century was outgrowing diapers that the realization became general that man cannot live by bread alone, even nutritionally speaking. Even with a diet perfectly adequate in calories, with a good mixture of proteins containing all the necessary amino acids,

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and with a good supply of pure carbohydrates, fats, and minerals, something more was needed not only to keep a body in good working order and free from disease, but even to allow it to grow at all.

The "discovery" of a vitamin is usually dated from its isolation in a fairly pure state, but recognition of a deficiency, and foods capable of supplying it, may long antedate such a discovery, and it may be years afterwards before the actual chemical composition is worked out. The cure of scurvy by feeding citrus juice or green vegetables was announced by Kramer over two hundred years ago, and a ration of lemon juice was made compulsory in the British navy while Washington was still President of the United States. Ever since then British sailors, who erroneously called their lemons "limes," have been nicknamed "limies." It was not, however, until two Norwegian scientists, Holst and Frölich, had spent several years, from 1907 to 1912, experimenting with guinea pigs that enough was known about the scurvy-preventing constituent of foods so that it could be admitted to the once exclusive family of accessory alphabetically-designated food factors, which Drummond named "vitamins" in 1920. The name "vitamine" had been coined by a Polish scientist, Casimir Funk, in 1911, for an approximately pure extract of rice polishings which would cure beri-beri. The term "amine," signifying in chemistry a certain type of nitrogenous compound, while applicable to vitamin B, is inappropriate for other vitamins. Drummond cleared his own conscience and soothed the outraged feelings of the chemists by amputating the final "e" and thus doing away with any chemical connotations the word might have. The final isolation and identification of the pure chemical substance which is vitamin C stripped bare required the combined work of Hungarian, British, German, and American workers from

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1927 until 1932. Who, then, can be said to have discovered vitamin C? The situation is almost as complicated for the other vitamins.

The vitamins are a peculiar hodge-podge of substances as unrelated as the drugs on an apothecary's shelf. The drugs constitute a natural grouping not because of what they are, but because of what they do, and this is true of vitamins also. The drugs have only one thing in common—they restore health or alter body functions when taken in relatively small quantities; the vitamins also have one thing in common—they *maintain* health and normal body functions when taken in relatively *minute* quantities. The amazing physiological effects they can bring about in almost incredibly small doses, and the widespread disorders which follow upon their absence, together with, until the last decade, their unknown chemical nature, has given them an aura of mystery and romance which has appealed to the popular imagination, and made them subjects of popular consciousness to a degree to which other food essentials, such as amino acids or minerals, may never aspire. But, actually, there is no longer very much excuse for segregating vitamins into an exclusive fraternity. One writer recently expressed the belief (or hope) that the name "vitamin" will eventually join the musty company of "phlogistic humors," "animalcules," and kindred antiquated terms. The striking physiological effects of small doses is also true of minerals, and nearly all the vitamins so far known to exist have yielded up the hidden secrets of their chemical nature to the relentless inquisitiveness of modern chemists. They do differ from most other food constituents, however, in that their main function is neither to furnish energy nor building material, but to serve as chemical tools by means of which the cells of the body are able to do their work.

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The general function of vitamins is much like that of the hormones of the body, but whereas the latter are "home-made," the vitamins have to be imported. Nevertheless, what is a hormone for one organism may be a vitamin for another. As vitamins they are not always imported in the active form in which they exist in the body, but may be altered or partially synthesized from mother substances in the food. The amounts required are so small that it has been found convenient to calculate them in millionths of a gram.

There started out to be only three vitamins, A, B, and C, but this simple A B C stage was very short-lived, and lasted only from about 1914 to 1920.

In 1922 the rickets-preventing vitamin D was shaken loose from A, under whose skirts it had been hiding, and at about the same time still another vitamin which had been hiding in the A complex was discovered. This one was found to be necessary for successful reproduction in rats; it was called the "anti-sterility factor X" by its discoverers, but was soon christened vitamin E. Between 1919 and 1926 the view progressed from a suspicion to a certainty that vitamin B also was not a unit. The old "vitamin B complex" has given birth to a whole litter of "B's," some of which have been dignified by separate letters of the alphabet (G, H, L, and M), while others have had to be content with numbers (B_1 to B_7), and still others, due to the hesitancy or conservatism of their deliverers, have merely been called "factors." One of the latest of this prolific family, the "P-P factor" which prevents pellagra, was so difficult to separate from some of the subnumeral B's that it was identified as a well-known chemical, nicotinic acid, before it was awarded a letter or even a number of its own, so it may never take the place which it well deserves in the vitamin alphabet.

Very recently the Hungarian scientist, Szent-Györgyi,

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was awarded a Nobel Prize for the discovery of a new vitamin P which he believed to be distinct from vitamin C. More recent work indicates that vitamin P has no real existence.

A few years ago a vitamin K was added to the list, and recently some Japanese chemists distracted scientific if not popular attention from other Japanese pursuits by announcing two new vitamins, L_1 and L_2 , said to be needed by rats to produce milk for their young. Only a few months ago monkeys, supplied with all the members of the B family known to be needed by human beings, still developed pellagra-like symptoms which were cured by Brewer's yeast or liver extract. The unknown factor was called vitamin "M."

The rapid multiplication of vitamins became so confusing that a special committee of scientific experts had to be set up to straighten out their names; but in spite of the committee a clear grasp of the true relations of the various members of the B group, at least, can only be acquired along with a good-sized headache, partly because one worker experimenting with chicks, another with rats, and another with dogs may find different effects from the same vitamin, different vitamins causing similar effects, and different effects caused by different dosages of the same vitamin. Professor McCoy of Cornell recently complained that the modern vitaminologist is afflicted with as many alphabetical vitamins as Job was with boils, and proposed that the League of Nations might set up a vitamin registry where each new or supposedly new factor for stimulating growth, or preventing skin sores, or what not, might be registered by number.

Now, however, things are getting better, at least in the B family, for B_1 , B_2 , B_6 (alias "factor I"), and the pellagra-preventing factors have all been positively identified chemically. Recently the "filtrate factor" of some writers, "factor II" of others, and "chick anti-dermatitis factor" of still

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others, has been identified with pantothenic acid. Some relief is afforded by Dr. Cowgill of Yale who claims that B₃, B₄, and B₅ have no real existence.

Not all vitamins are needed by all animals, nor do they affect all animals in a similar manner. Man, monkeys, and guinea pigs, for instance, are the only animals known to require vitamin C; others presumably are capable of making their own, or harbor bacteria which do it for them. The nicotinic acid which prevents and cures human pellagra is not identical with the B₆ which prevents rat pellagra, and apparently the representative of the B family which prevents a skin disease in birds is different from either; as noted above, recent work indicates that the latter may be identical with pantothenic acid, a substance found in cells of all kinds of organisms from bacteria to mammals, and indispensable to all. For some organisms it is a home-made product, for others a vitamin. How we get ours is as yet unknown. There is reason to believe that thiamin (B₁) and nicotinic acid are likewise universally needed substances. This appears not to be true of some of the other vitamins.

There are at least ten different kinds of vitamin D, not all of which are equally effective in rats and chicks, and no one actually knows how they might work in lizards or earthworms, if needed at all. It is generally thought that rats and man have much in common nutritionally—any food handler will agree to this! Therefore, until evidence to the contrary comes to light, it is assumed that what is necessary to keep a rat hale and hearty is also necessary for *Homo sapiens*.

The vitamin potency of various food substances was until recently determined by a "biological assay" method; a diet was prepared containing adequate quantities of all food requirements except the vitamin to be tested. This was fed to rats (or other experimental animals) until they began to

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show symptoms of deficiency. They were then treated to the same diet *plus* varying amounts of the foods to be tested. The smallest amount which would cause certain minimum improvements in growth or other effects was called a unit. Not all nutrition workers originally used the same units, but the Health Organization of the League of Nations brought order out of confusion by adopting standard "international units."

As the pure chemical substances which constitute the vitamins are discovered, one after another, weights of these pure substances are substituted for the standards of reference originally adopted. The weights are best expressed in micrograms (one one-millionth of a gram). The present international unit of vitamin A is equivalent to 0.6 micrograms of carotene, of B₁ to 3½ micrograms of thiamin, of C to 50 micrograms of ascorbic acid, and of D to 0.025 micrograms of crystalline vitamin D. No international units of other vitamins of the B group or of E or K have yet been proposed. The older units of vitamin B₂ or G were based on the whole complex, before riboflavine, nicotinic acid, and others were segregated.

It is still necessary to test for most vitamins by the laborious and tedious "biological assay" method, but simple chemical tests are being discovered. A few years ago if some inquisitive person wished to know how much vitamin C there was in a new variety of apple, he would have had to play dietetic nursemaid for a half-dozen pens of guinea pigs for three months, and then perform careful autopsies on them, whereas now he can obtain the same information in a few minutes with a test tube and some chemicals.

There has been so much talk of vitamins in recent years that people have become very vitamin-conscious. Food and drug manufacturers, as might have been expected, were

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quick to cash in on this interest and to help it along, as they have many other popular interests, by large-scale advertising. Foods are often advertised as containing this or that vitamin when an average human portion of the food would contain barely enough to satisfy a mouse. Drugstores have found concentrated and purified vitamins almost as much a gold mine as are cathartics and liver tonics. Many of the ideas fostered by drug manufacturers have proved to be pure fads, and there has been a large body of conservative-minded citizens among us, including many in the medical profession, who felt that the use of supplementary concentrated vitamins was neither necessary nor desirable. They remembered that people were able to remain in at least an apparently good state of health hundreds of years before vitamins were dreamed of, and that some of our more primitive "poor relations" in Africa and Central Asia who haven't yet dreamed of vitamins seem to be just as hale and hearty as the consumers of drugstore concentrates.

But time marches on at a faster gait in our civilized communities than in primitive ones, and there have been far greater changes in our diets, our work, and our recreation. We use larger amounts of high calorie foods, such as sugar, white flour, polished rice, and lard, from which we have extracted all the vitamins; we subject other foods to storage, cooking, crushing, or other manipulations which at least partly destroy the vitamins we haven't extracted; we throw away the outer parts of vegetables and the blood and many special organs of the animals we eat, thereby eliminating the parts especially rich in vitamins; we have circumvented Nature's plan for letting us produce vitamin D in our own sun-tanned skins by introducing into our lives such things as smoke palls, clothing, windows, and indoor occupations. We have surrounded ourselves with labor-saving devices which

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make us less physically active, thus reducing the amount of food we consume and incidentally the quantity of vitamins. Even if we eat an abundance of foods known to contain vitamins, and stuff ourselves with the fruits and vegetables that health enthusiasts are constantly recommending to us, unless our selection is carefully made, we could very easily fall short of the amounts of vitamins which are now considered ideal for perfect health.

A few years ago, before we knew what large quantities of vitamins a human body would use if they were available, and before we had any very easy or accurate methods of determining the actual amounts of different vitamins in our foods, it was still thought that common foods could be relied upon to supply us with all we needed, even if we ate a normal amount of the devitaminized foods which play such a prominent part on modern dining tables. Actually, a person eating an ordinary mixed diet with a large amount of sugar and white flour, with a fair amount of milk, butter, whole cereal, vegetables, and fresh fruits, would never suffer from beri-beri, pellagra, scurvy, or diseased eyes, or become a dwarf. He would probably consider himself in good health, because he was in as good health as the average of his neighbors. He probably wouldn't consider it anything but natural if he had fairly frequent colds, had unhealthy teeth and gums, had a little difficulty in adjusting himself to seeing in the dark, had a not-too-good appetite, was frequently afflicted with a tired feeling and headaches, was subject to gassiness and constipation, occasionally had fits of gloominess and depression, and was inclined to have a tantrum if his wife inadvertently passed a forcing bid in a bridge game.

On the other hand, it has been shown repeatedly that when more abundant vitamins are taken, a state of "super-health" is achieved. What most of us consider normal

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health is actually not the best that we could have. Ill health from such common causes as unhappy relations with one's wife or with the stock market, or poor digestion, is sometimes improved to an astonishing degree. Many a case of poorly defined ill health blamed on heritage or the inscrutable will of the Lord is due to nothing more than insufficient vitamins in our daily bill of fare. A recent report on treatment of hardening of the arteries and accompanying diseases of the blood-system and kidneys showed that a high proportion of them responded better to large doses of vitamins and minerals than to any other form of treatment. Many cases of chronic arthritis are similarly benefited.

Julian Huxley said that if he were able to dictate the food habits of a nation for one generation, he could add one cubit to their stature and double their resistance to disease. British medical authorities have gone so far as to say that 99 per cent of the so-called common illnesses are directly or indirectly due, at least in part, to vitamin deficiencies.

There is reason to believe that generous supplies of vitamins and minerals, such as would be obtained either by a careful and intelligent choice of natural foods, or by the use of supplementary vitamins, would increase the expectancy of life from the seventy years that were awarded to our ancestors, to seventy-seven. Lest anybody still far removed from that age might not fully appreciate what an asset that would be, he should pause to think that the added seven years is merely a visible proof of a 10 per cent better life throughout the preceding seventy, and that the man who has extended his span of years to that extent had the vim and vigor of forty-five when the family Bible said he was fifty.

Of course there are many other causes of poor health than inadequate vitamins, and vitamins alone cannot make a man well who is suffering from an infectious disease, or

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glandular disturbances, or a cancer. Yet even in such conditions extra vitamins may be of great benefit. Extra vitamin B is required when the metabolism is stimulated by an overactive thyroid or by fever, and extra vitamin C is needed when the toxic products of infection, metal poisoning, etc., combine with large amounts of it and take it out of circulation.

Yet disease nearly always leads to lowered rather than heightened intake of vitamins. Many diseases have a toxic, exhaustive effect on the nervous system, leading to insomnia. Recent experiments show that all ordinary types of insomnia are helped by large doses of either vitamin B or vitamin C, or both. These vitamins have been hailed as ideal sedatives for alcoholics suffering from delirium tremens, for hyperthyroid patients worn down by their overactive glands, for elderly people sleepless because of hardening arteries in the brain, and for convalescents from operations or debilitating diseases. Vitamin treatment which gets at the fundamental causes of insomnia is a great advance over the older method of merely masking symptoms by the use of stupefying drugs.

It is obvious that human vitamin deficiencies are nearly always multiple in Nature. Pure dietary deficiencies can be produced experimentally in animals by the careful and laborious preparation of a diet containing enough of all necessary food substances except one vitamin or mineral. But even when conscious efforts are made to obtain a single deficiency it is very difficult to do. When foods are withheld to eliminate one vitamin, others are often found to have been eliminated also. Few human foods contain single vitamins, so it is extremely likely that any diet or condition which results in such extensive deprivation of one vitamin as to produce clear symptoms of its lack, will at the same time be lacking in other vitamins, though possibly to a

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milder degree. Any condition which interferes with the absorption of vitamin A, for instance, is also liable to interfere with the absorption of other fat-soluble vitamins. Any diet lacking in one constituent of the vitamin B complex is also liable to be deficient in others. The amazing results recently obtained by treatment of pellagrins with nicotinic acid fall short of complete cure unless some vitamin B₁ is provided also. The symptoms due to one deficiency may so overshadow those due to others that the latter escape notice, but in all such cases treatment with a single pure vitamin is almost sure to fall short of a complete cure.

To sum up, the vitamins known or believed to be necessary for normal human health, with modern ideas of the amounts necessary, are as follows:

Soluble in fats:

- A, a derivative of carotene; needed for normal growth, healthy eyes, and resistance to infection. Normal daily needs from 3000 units in infants to 6000–8000 in adults and 9000–10,000 in expectant and nursing mothers.
- D, irradiated “sterols”; needed for proper calcium and phosphorus metabolism, to produce healthy bones and teeth, and to prevent rickets. Normal daily needs for children in first year 800–1200, in second year 800, thereafter gradually less.
- E, an alcohol, tocopherol; needed for normal reproduction in rats, and probably in man also. Normal daily needs unknown, but small except during pregnancy.
- K, a naphthoquinone; needed for production of prothrombin, to facilitate the clotting of blood. Apparently needed by man only in unusual circumstances.

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Soluble in water :

- B₁, thiamin; needed for healthy nerves, good appetite, and normal metabolism of carbohydrates; prevents beri-beri. Normal daily needs, 100 units in infants, 300–600 in adults, 400–800 in expectant and nursing mothers.
- B₂, or G, riboflavine; needed for normal growth in rats, and for continued health in dogs, but little is known about its effects in man. Aids in metabolism of carbohydrates and proteins. Normal daily needs unknown, possibly 10–30 units.
- P-P factor, nicotinic acid; needed for prevention of pellagra and sprue. Normal daily needs unknown, but very small.
- C, ascorbic (or cevitamic) acid; needed for healthy teeth, normal development of supportive and connective tissues, and resistant capillaries; prevents scurvy. Normal daily needs, 100 units for infants, 200 for adults, and 400 for expectant and nursing mothers.